

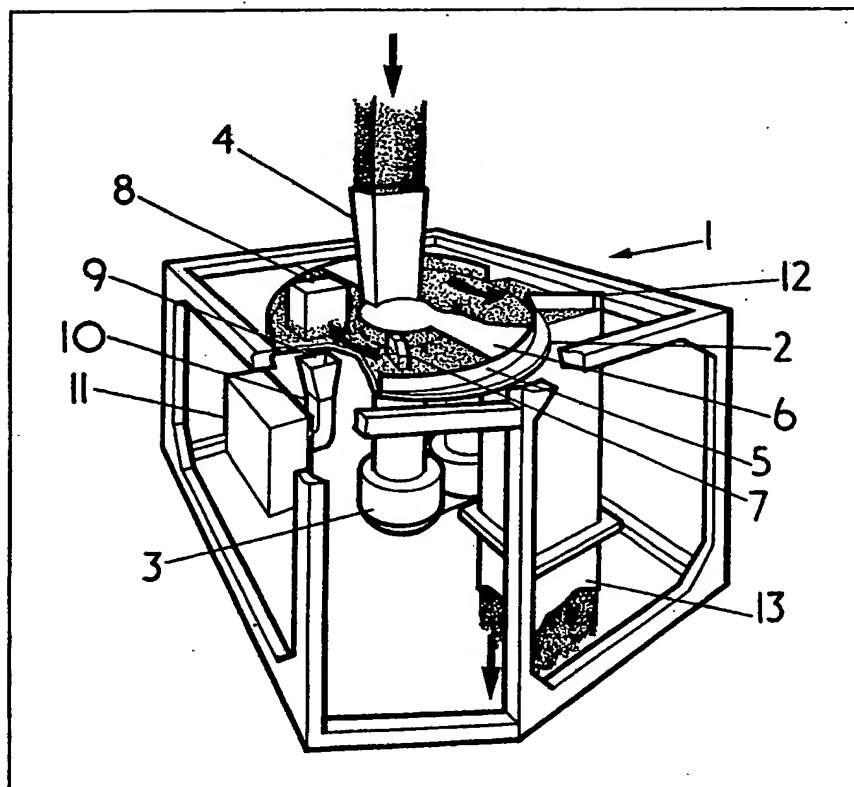
(12) UK Patent Application (19) GB (11) 2 122 741 A

- (21) Application No 8217990
 (22) Date of filing 22 Jun 1982
 (43) Application published 18 Jan 1984
 (51) INT CL³
 G01N 22/04 23/203
 23/223
 (52) Domestic classification
 G1A A4 BG D2 G1 G2 G7
 P9 R2 S6 T14 T15 T20
 T22 T23 T3 T8 T9
 G1N 19B2A 19C7 19F7B
 19H5D5
 U18 1263 2144 2159
 G1A G1N
 (56) Documents cited
 GBA 2043876
 GBA 2004371
 GB 1212932
 GB 1177067
 (58) Field of search
 G1A
 G1N
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(54) Improvements in monitoring coal

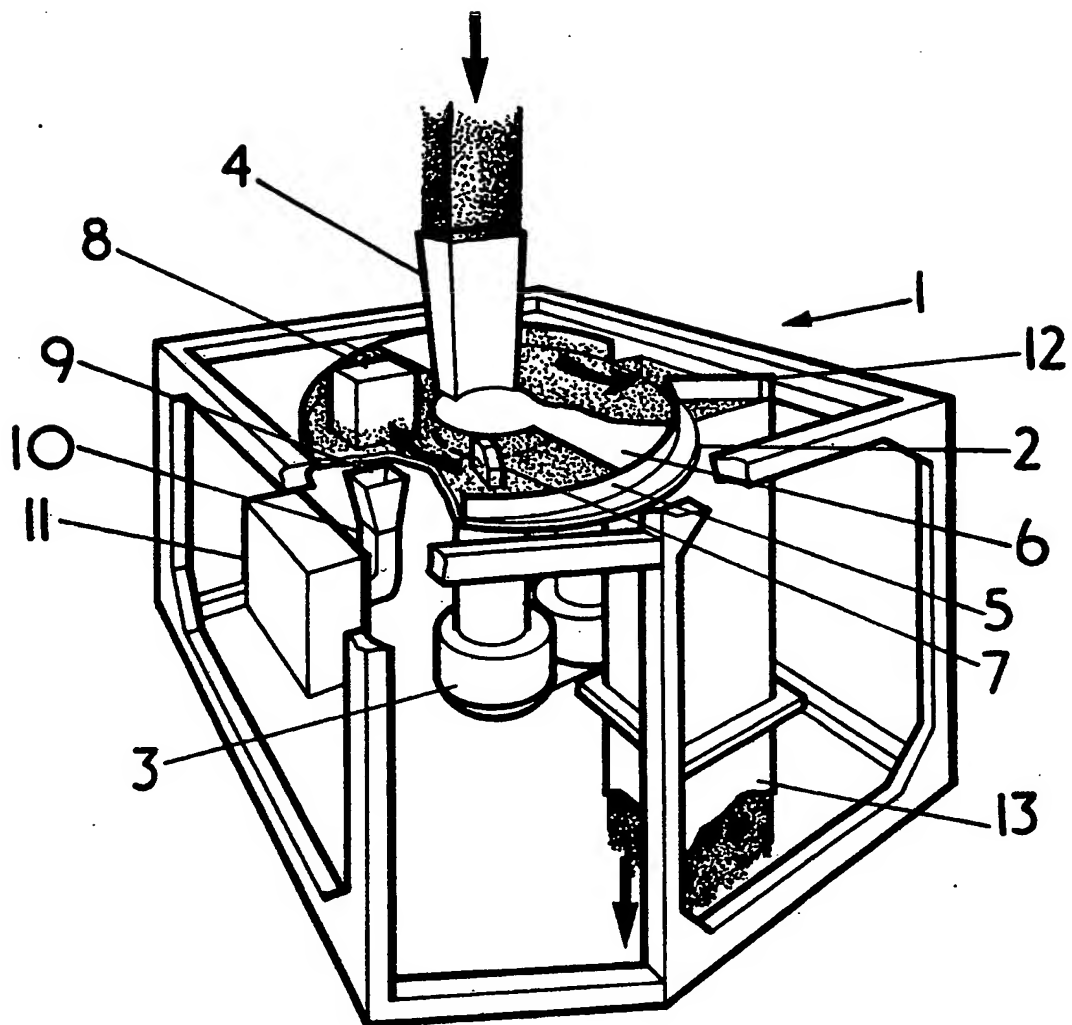
(57) An instrument for determining a first characteristic of a material, eg ash in coal, by X-radiation comprises a turntable 2 with material feeding means 4. An X-radiation source and

detector unit 7 determines the first characteristic, and a microwave source 8 and detector unit 9, 10, 11, determine a second characteristic of the material, eg moisture in coal. The turntable 2 is transparent to microwaves in at least the region traversed by the microwaves.



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SPECIFICATION Improvements in monitoring coal

This invention concerns improvements in monitoring coal and other particulate solid materials such as minerals, more especially it concerns the combined measurement of characteristics of the material by electromagnetic radiation of two different types.

The use of electromagnetic radiation, for example X-rays or gamma radiation, is known for the analysis of finely divided or particulate solid materials. For example, there is a commercially available instrument in fairly widespread use within the coal industry which utilises back-scattered X-radiation to analyse coal samples for ash content. The basic method used involves the correction for iron fluorescent radiation by the use of filters, and is described in British Patent Specification No. 975,303. The instrument is capable of operating on continuously supplied samples of coal and relies upon a turntable arrangement as described in our British Patent No. 1,177,067.

In the analysis of elements or components such as ash in coal or other minerals, the use of a spectrum of X-radiation or two different energies of X-radiation have been suggested in order to detect more than one component or to correct the determination of one component by allowing for interfering elements.

In this specification, reference will be made to the monitoring of coal, which includes coal-like materials such as brown coal or lignite, peat, shale, coke and like solid fuels, but it is to be understood that the present invention may be applied to other solid particulate materials including especially minerals but also including agricultural produce, raw or processed, and chemicals.

The present invention provides an apparatus for the determination of at least two characteristics of a particulate material, comprising a horizontal table mounted for rotation about a vertical axis, material feeding means arranged to feed material onto the table, means for levelling the upper surface of the material supplied onto the table, a first electromagnetic radiation source operating in the X-radiation band with an associated detector and a second electromagnetic radiation source operating in the microwave band and an associated detector, the second radiation source and the detector being mounted on opposite faces of the table and at least a portion of the table being substantially transparent in at least the microwave band.

The first radiation source and the detector, operating in the X-radiation band may also be mounted on opposite faces of the table, so that at least a first characteristic of the material is measured by X-ray absorption. In such a case, the table must also be substantially transparent to X-radiation in the appropriate waveband. However, absorption determination does depend significantly upon the mass of material per unit

area traversed by the X-rays and unless this can be substantially constant, which will depend upon the actual design of the apparatus as well as the physical characteristics and constancy of supply of the material, it is probably more reliable to operate on back-scatter and/or fluorescence detection. In the case of back-scatter and/or fluorescence detection, the first radiation source and the detector will be mounted above the table, so as to irradiate a levelled sample. The actual radiation source and detector themselves form no part of the present invention and suitable sources and detectors are known in the art, together with suitable signal processing means. Depending upon the material being examined by the apparatus, back-scattered and/or fluorescent radiation may be detected and the detector may provide a signal corresponding to a single characteristic or to a plurality of characteristics, and the signal may be processed to yield concentration values for a single characteristic, a single characteristic corrected for the presence of other, interfering characteristics, a plurality of characteristics or some combination thereof. In the case of coal, the primary characteristic determined regularly is ash content; this may be determined alone, corrected for the presence of iron and/or other elements, or determined together with other components especially the "pollutants" such as sulphur, chlorine and nitrogen.

The second radiation source operates in the microwave band and is particularly suitable for the determination of moisture in the material. The source of microwaves may be a klystron source but is preferably a Gunn diode, which is preferably chopped at some convenient frequency for ease of detection, suitably at about 1.0 kHz. The moisture content of the sample attenuates the signal, so that the detector yields a pulsating direct voltage. The standing voltage is suitably removed by a.c. coupling and a tuned filter rejects electrical noise. The filter yields an a.c. sine wave with amplitude proportional to the power collected by the detector, and this is rectified, filtered and presented to a logarithmic converter. The converter linearises the output of the apparatus with respect to water content. The final output signal is inversely proportioned to the attenuation caused by the material. If the moisture content versus the attenuation properties of a given coal are known, then the moisture in any unknown sample may be determined from the apparatus output.

The turntable of the present invention must be substantially transparent to at least microwaves, and is suitably of a synthetic plastics material such as polypropylene or polyvinyl chloride. Other plastics or other materials having the appropriate properties may of course be used. The plastics turntable is preferably provided with wear-resistant parts, conventionally of steel, since prolonged usage especially with abrasive materials could cause damage.

The apparatus of the invention, when measuring ash content and moisture content in

coals, is particularly convenient for the production of calorific values of the coal samples being inspected by suitable processing of the output signals of the X-ray and micro-wave section. In addition, the moisture content is especially useful in monitoring handling properties for coals for power generation.

The invention will now be described with reference to the accompanying drawing, which is a perspective view, partly cut away, of an apparatus according to the present invention.

The apparatus is mounted within a housing generally indicated by 1. A plastics turntable, 2, is powered by a motor and gearbox unit, 3.

Powdered coal samples, generally in the size range — 5 mm, are fed through an input chute, 4, onto the turntable 2. A fixed sidewall or deflector, 5, controls movement of material on the turntable. The coal is levelled and compacted by a spiral pressure plate, 6, before passing under an ash monitor head, 7. The head 7 carries an isotope source of X-rays, (the isotope may be Pu238, or Cd109) and a conventional proportional detector. Aluminium filters may be chosen to compensate for the average iron content of the coal being examined. The ash monitor head operates on a backscatter measurement for ash.

Mounted above the turntable is the Gunn diode microwave source, 8, and mounted directly below the turntable is a detector horn, 9, with a wave guide, 10, leading to a microwave detector and processor unit, 11. The powdered coal sample on the turntable is urged by the deflector 5 in a generally outward direction until a plough, 12 urges the outer section into a discharge chute, 13, which feeds back into the coal stream.

The apparatus has shown itself to be convenient and reliable in extended tests and exhibits good precision compared with classical laboratory analysis. Used with a common signal processing unit, the apparatus can give good results for calorific value of coals to be supplied to a customer.

CLAIMS

1. An apparatus for the determination of at least two characteristics of a particulate material, comprising a horizontal table mounted for rotation about a vertical axis, material feeding means arranged to feed material onto the table, means for levelling the upper surface of the material supplied onto the table, a first electromagnetic radiation source operating in the X-radiation band with an associated detector, and a second electromagnetic radiation source operating in the microwave band and an associated detector, the second radiation source and the detector being mounted on opposite faces of the table and at least a portion of the table being substantially transparent in at least the microwave band.

2. An apparatus according to claim 1, wherein the X-radiation source and detector are both mounted above the table and the detector detects backscatter matter and/or fluorescence radiation from the levelled material.

3. An apparatus according to claim 1 or 2, wherein the microwave source is a Gunn diode.

4. An apparatus according to claim 3, wherein the output of the diode is chopped at about 1.0 kHz.

5. An apparatus according to any one of the preceding claims, wherein the transparent part of the table is of polypropylene or polyvinyl chloride.

6. An apparatus according to claim 1, substantially as hereinafter described with reference to the accompanying drawing.

7. A method of determining at least two characteristics of a particulate material comprising the use of an apparatus according to any one of the preceding claims.

8. A method according to claim 7, wherein the particulate material is coal.

9. A method according to claim 8, wherein X-radiation is used to determine at least the ash content of the coal and microwave radiation is used to determine the moisture content of the coal.

10. A method according to claim 9, wherein the output signals from the radiation detectors are processed to give, in addition to ash and moisture content, a value representative of the calorific value of the coal.

New claims or amendments to claims filed on 21st June, 1983

Superseded claims 1—10

New or amended claims:— 1—9

CLAIMS

1. An apparatus for the determination of at least two characteristics of a particulate material, comprising a horizontal table mounted for rotation about a vertical axis, material feeding means arranged to feed material onto the table, means for levelling the upper surface of the material supplied onto the table, a first electromagnetic radiation source operating in the X-radiation band with an associated detector and a second electromagnetic radiation source operating in the microwave band and an associated detector, wherein the first radiation source and detector are mounted above the table and the detector detects backscatter and/or fluorescence radiation from the levelled material and the second radiation source and the detector are mounted on opposite faces of the table, at least the portion of the table traversed by microwave radiation being substantially transparent in at least the microwave band.

2. An apparatus according to claim 1, wherein the microwave source is a Gunn diode.

3. An apparatus according to claim 2, wherein the output of the diode is chopped at about 1.0 kHz.

4. An apparatus according to any one of the preceding claims, wherein the transparent part of the table is of polypropylene or polyvinyl chloride.

5. An apparatus according to claim 1, substantially as hereinafter described with reference to the accompanying drawings.

6. A method of determining at least two characteristics of a particulate material comprising the use of an apparatus according to any one of the preceding claims.
- 5 7. A method according to claim 6, wherein the particulate material is coal.
8. A method according to claim 7, wherein X-radiation is used to determine at least the ash
- 10 content of the coal and microwave radiation is used to determine the moisture content of the coal.
9. A method according to claim 8, wherein the output signals from the radiation detectors are processed to give, in addition to ash moisture content, a value representative of the calorific value of the coal.
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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1984. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.